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Wide-Range Logarithmic Radiometer for Measuring High Temperatures

The problem:

Measuring rapid variations of the temperature of a white-hot charred body at 2000° to 3000°K.

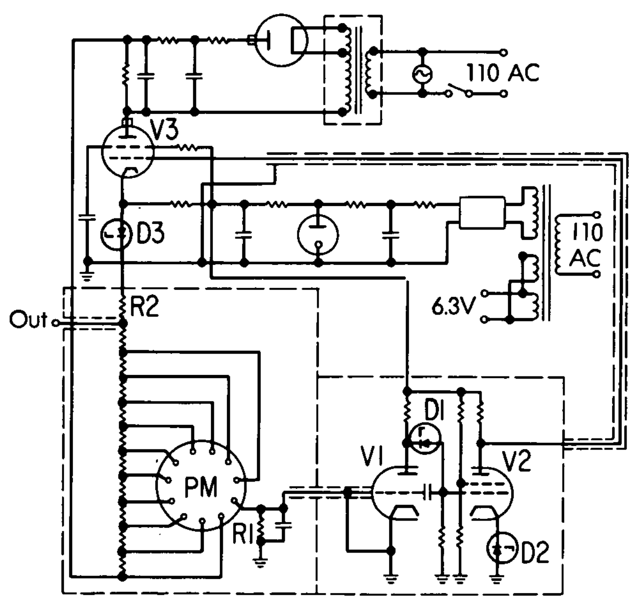
The solution:

A filter radiometer utilizing a photomultiplier circuit in which a direct-coupled amplifier varies dynode voltage so as to maintain constant anode current; the logarithm of the voltage applied to the photomultiplier is a nearly linear function of the reciprocal temperature of the white-hot source.

How it's done:

Examination of a plot of the radiant energy emitted in the near ultraviolet by a nearly black body obeying Wien's law reveals that there is approximately a four-order-of magnitude change of radiant energy over the interval 2000° to 3000°K and that it is nearly constant over the range of emissivities commonly associated with charred bodies. In comparison, the emission of radiant energy in the infrared is a more sensitive function of emissivity. Accordingly, the radiometric measurement of temperature is accomplished with the logarithmic photometer depicted in the figure by passing radiation emitted from the white-hot body through a filter which transmits largely in the 320 nm region before it falls onto the sensitive surface of the photomultiplier.

The output current of the photomultiplier anode generates a voltage across R1; this voltage is directly coupled to the grid of V1. The plate voltage of V1 is direct-coupled to V2 via Zener diode D1, and thus is differentially compared with the Zener potential across D2. The output plate voltage of V2 in turn is coupled directly to a series-control tube, V3, and its cathode bias, Zener diode D3. The circuit elements are adjusted so that the output current through R1 is of the order of 1 microampere; any variation



in the voltage drop across R1 is greatly amplified and applied to the control grid of V3. As a result, the total potential applied to the photomultiplier dynode resistor string is varied and the initial conditions at R1 are re-established. The logarithm of the voltage that must be supplied to the photomultiplier to maintain design potential across R1 is nearly a linear function of the logarithm of light intensity. The circuit can change the dynode voltage from 25 to

(continued overleaf)

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125 volts per stage, corresponding to a total change of photomultiplier gains of a million to one. The drop across resistor R2 (less than 1 volt) is measured and taken as an indication of the total photomultiplier supply voltage.

The radiometer can be calibrated with a disappearing-filament pyrometer when both instruments are viewing a flat graphite surface maintained at white heat. The logarithm of the photomultiplier voltage bears a closely linear (±0.5%) relationship to the reciprocal of the absolute temperature,

$$\log V = K(1/T) + C$$

over the range of 2000° to 3000°K with a 320-nm filter at a 7-nm half-bandwidth.

Notes:

1. The response of the radiometer was checked with a pulsed ultraviolet glow lamp and found to be of the order of 50 microseconds.
2. Requests for additional information may be directed to:

    Technology Utilization Office
    Ames Research Center
    Moffett Field, California 94035
    Reference: TSP-71-10498

Patent status:

No patent action is contemplated by NASA.

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